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The main accomplishments during this grant are in the area of routing algorithms for binary cube networks.

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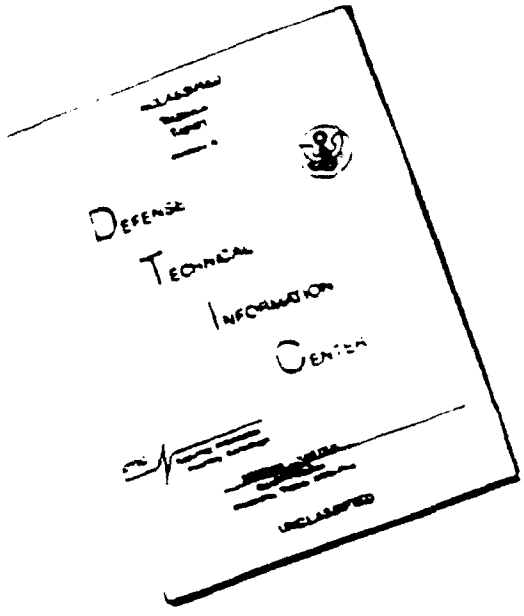

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Final Report for AFOSR grant AFOSR-89-0382 with Yale and Harvard Universities

S. LENNART JOHNSSON

January 1993

1. Summary

The main accomplishments during this grant are in the area of routing algorithms for binary cube networks.

It is well known that meshes are subgraphs of binary cubes. Binary-reflected Gray codes are often used to assign data elements to nodes in the cube in order to preserve adjacency. It has been conjectured that the minimum number of element exchanges to perform the conversion between the standard binary code and the binary-reflected Gray code is equal to $\frac{M}{n}(n-1)$, where M is the size of the data set in each node, and n the dimension of the binary cube. We have shown this conjecture to be false, and provided an algorithm that realizes the conversion in time $\frac{2}{3}M$ for $n > 2$. For $n = 2$ the conversion time has been known to be $\frac{M}{2} + 1$. Our algorithm for $n > 2$ is quite simple.

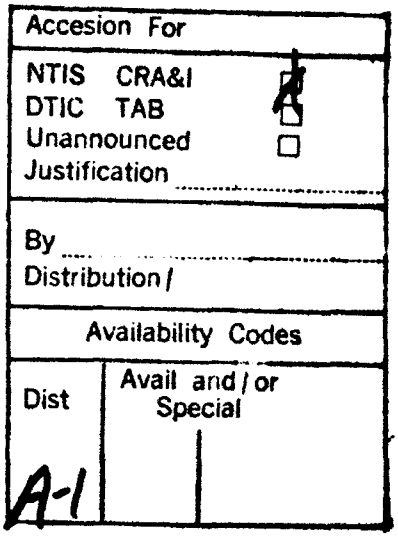
In a joint work with Alan Edelman of UC Berkeley, and Steve Heller of Thinking Machines Corp. we have also shown that the ability to construct pipelined algorithms for binary code to binary-reflected Gray code conversion is related to the ability to factor without pivoting a matrix defining the conversion between binary code and binary-reflected Gray. The matrix representation provides a convenient way of characterizing algorithms for a class of routing tasks.

Two communication algorithms devised earlier has been implemented on the Connection Machine systems CM-2 and CM-200 in collaboration with Jean-Philippe Brunet of Thinking Machines Corporation, and Ralph Brickner and Bill George of Los Alamos National Laboratories. Both algorithms increases the effective use of the communications bandwidth of the Connection Machine systems. The all-to-all broadcast routine optimally yields a performance enhancement by a factor of two over alternate ways of performing the operation. In practice and improvement by up to a factor of ten has been observed. For the polyshift operation an improvement by a factor of up to four has been observed.

In collaboration with Kapil Mathur of Thinking Machines Corporation and Zdenek Johan of Stanford University we implemented randomization techniques for sparse gather/scatter operations on the Connection Machine systems CM-2 and CM-200. The gather/scatter utilities improved the performance by up to a factor of five. For large unstructured finite element grid codes the the result is that no more than about half the time is spent in communication.

The all-to-all broadcast routine is currently being extended to all-to-all reduction. During the fall we initiated two efforts towards the understanding of effective load-balancing for

dynamic, unstructured computations, with the goal being applications such as particle-in-cell codes.



During the grant, results of the research have appeared in several journal and conference publications, and been disseminated in invited lectures.

2. Journal publications

"Boolean Cube Emulation of Butterfly Networks Encoded by Gray Code" (with Ching-Tien Ho), to appear in the *Journal of Parallel and Distributed Computing.*

"POLYSHIFT Communications Software for the Connection Machine System CM-200", (with Ralph Brickner and William George), to appear in the *Journal of Scientific Programming.*

"An Efficient Algorithm for Gray-to-Binary Permutation on Hypercubes", (with Ching-Tien Ho and M.T. Raghunath), to appear in *Journal of Parallel and Distributed Computing.*

"Minimizing the Communication Time for Matrix Multiplication on Multiprocessors", to appear in *Journal of Parallel Computing.*

"Optimal Communication Channel Utilization for Matrix Transposition and Related Permutations on Boolean Cubes", (with Ching-Tien Ho) to appear in the *Journal of Discrete Applied Mathematics.*

"Block Cyclic Dense Linear Algebra", (with Woody Lichtenstein), *SIAM J. of Sci. Comp.*, vol. 14, no. 5, 1993.

"Embedding Hyper-pyramids in Hypercubes", (with Ching-Tien Ho), to appear in *IBM Journal of Research and Development*, 1992.

"Communication Primitives for Unstructured Finite Element Simulations on Data Parallel Architectures", (with Kapil K. Mathur) *Computig Systems in Engineering*, vol. 3, Nos 1 - 4, pp. 63 - 72, 1992. (Also presented at *Symposium on High Performance Computing for Flight Vehicles*, December 7 - 9, 1992.)

"Local Basic Linear Algebra Subroutines (BLAS) on the Connection Machine System CM-200", (with Luis Ortiz), *International Journal of Supercomputer Applications*, vol. 7, no. 1, 1993.

"All-to-All Broadcast with Applications on the Connection Machine", (with Jean-Philippe Brunet), *International Journal of Supercomputer Applications*, vol. 6, no 3, pp. 241- 256, 1992.

"A Data Parallel Finite Element Method for Computational Fluid Dynamics on the Connection Machine Systems", (with Zdenek Johan, Tom Hughes and Kapil K. Mathur), *Computer Methods in Applied Mechanics and Engineering*, vol. 99, no. 1, pp. 113 - 134, August 1992.

"Communication Efficient Multi-Processor FFT", (with Michel Jacquemin and Robert L. Krawitz), *Journal of Computational Physics*, vol. 102, no. 2, pp. 381-397, October 1992.

"Cooley-Tukey FFT on the Connection Machine", (with Robert L. Krawitz), Journal of *Parallel Computing*, vol. 18, no. 11, pp. 1201-1221, 1992.

"Generalized Shuffle Permutations on Boolean Cubes", (with Ching-Tien Ho), *Journal of Parallel and Distributed Computing*, vol 16., no. 1, pp. 1-14, 1992.

"The Parallel Multipole Method on the Connection Machine", (with Feng Zhao), *SIAM J. Sci. Stat. Comp.*, vol. 12, no. 6, pp. 1420-1437, November 1991.

"Performance Modeling of Distributed Memory Architectures", *Journal of Distributed and Parallel Computing*, vol. 12, no. 4, pp. 300-312, 1991.

"QCD on the Connection Machine: Beyond *Lisp", (with Ralph G. Brickner and Clive F. Baillie), *Computer Physics Communications*, vol. 65, pages 39-51, 1991.

"A Data Parallel Implementation of an Explicit Method for the Compressible Navier-Stokes Equations for Three-Dimensional Channel Flow", (with Pelle Olsson) *Journal of Parallel Computing*, vol. 14, no. 1, pp. 1- 30, 1990.

"Optimizing Tridiagonal Solvers for the Alternating Direction Method on Boolean Cube Multiprocessors", (with Ching-Tien Ho), *SIAM Journal on Sci. Stat. Comp.*, vol. 11, no. 3, pp. 563-592, May 1990.

"Data Structures and Algorithms for the Finite Element Method on a Data Parallel Supercomputer", (with Kapil Mathur), *International Journal of Numerical Methods in Engineering*, vol. 29, no. 4, pp. 881-908, April 1990.

"Embedding Meshes in Boolean Cubes by Graph Decomposition", (with Ching-Tien Ho), the *Journal of Parallel and Distributed Computing*, vol. 8, no 4, pp. 325-339, April 1990.

"Experience with the Conjugate Gradient Method for Stress Analysis on a Data Parallel Supercomputer", (with Kapil K. Mathur) *International Journal on Numerical Methods in Engineering*, vol. 27, no. 3, pp. 523-546, December 1989.

"Boundary Modifications of the Dissipation Operators for the Three-Dimensional Euler Equations, (with Pelle Olsson), *Journal of Scientific Computing*, vol. 4, no. 2, pp. 159-195, June, 1989.

"The Finite Element Method on a Data Parallel Computing System", (with Kapil Mathur), *Int. Journal of High-Speed Computing*, vol. 1, no. 1, pp. 29 - 44, May 1989.

"Histogram Computation on Distributed Memory Architectures" (with Dimitris C. Gerogiannis and Stelios C. Orphanoudakis), *Journal on Concurrency: Practice and Experience*, vol. 1, no. 2, pp. 219-237, December 1989.

"Spanning Graphs for Optimum Broadcasting and Personalized Communication in Hypercubes", (with Ching-Tien Ho), *IEEE Trans. Computers*, Vol. 38, No. 9, pp. 1249-1268, September, 1989.

3. Supported Graduate students

Ted Nesson, Harvard University, part time in 1992.

4. Invited presentations

"Massively Parallel Computing", *AFOSR Workshop on Computational Electromagnet-*

ics, **Hanscom Air Force Base, Mass., December 3 - 4, 1992.**

"Efficient Massively Parallel Supercomputing", *The Fifth ECMWF Workshop on the Use of Parallel Computers in Meteorology'*, **Reading, England, November 23 - 27, 1992.**

"Scalable Scientific Libraries", *First International Heinz Nixdorf Symposium on Parallel Architectures and their Efficient Use*, **Paderborn, Germany, November 11 - 13, 1992.**

"Techniques for High Performance Scientific Computing", *Second Symposiym on the Frontiers of Massively Parallel Computation*, **Fairfax, Virginia, October 10 - 12, 1992.**

"Scalable Parallel Libraries and the Connection Machine system CM-5", Rensselear Polytechnique Institute, September 10, 1992.

"Techniques for High Performance Scientific Computing", *Parallel Aspects of Numercial Linear Algebra*, **Copenhagen, August 24 - 25, 1992.**

"Scientific Libraries for Scalable Architectures", IBM Workshop on *Scientific Libraries for Parallel Architectures*, **Oberlech, July 12 - 18, 1992.**

"Run-Time system support for distributed memory machine compilers", *Third Workshop on Compilers for Parallel Computers*, **Vienna, July 6 - 8, 1992.**

"Computational Fluid Dynamics on Massively Parallel Architectures" , 2nd *International Conference on Spectral and High Order Methods*, **Montpellier, June 22 - 26, 1992.**

"Scientific Libraries for Scalable Architectures", 7th *IMACS Conference on Compter Methods for PDEs*, **New Brunswick, June 22 - 24, 1992.**

"A Data Parallel Finite Element Method for CFD on the Connection Machine Systems", *Parallel CFD '92, Implementation and Results Using Parallel Computers*, **Rutgers University, New Brunswick, May 18 - 20, 1992.**

"Massively Parallel Computing: Numerical and Computer Science issues", *The ONR Workshop on Domain-Specific Parallelism; CS, NA, Physics*, **Los Angeles, CA, May 14 - 15, 1992.**

"Communication primitives and their implementation for distributed memory architectures", *Standards for Message Passing in a Distributed Memory Environment*, **Williamsburgh, VA, April 29 - 30, 1992.**

"Mathematical Software", *NASA Workshop on Systems Software and Tools for High Performance Computing Environments*, **Pasadena, CA, April 14 - 16, 1992.**

"Electronic Parallel Architectures", *AFOSR and NSF Workshop on Reconfigurable Free-Space Optical Interconnect*, **Boulder, CO, March 11 - 13, 1992.**

"Massively Parallel Computing: MIMD vs. Data Parallel", *Compcon 92*, **San Francisco, February 24 - 28, 1992.**

"Algorithms and Software Techniques for Scientific Applications on Scalable Architectures", *Workshop on Parallel Computing for 3D Plasma Simulation*, **Albuquerque,**

January 15 - 17, 1992.

1991

"Scientific Libraries for Scalable Architectures", The Danish Institute of Technology, Copenhagen, December 19th, 1991.

"How can Models Promote Main Stream Parallelism", Panel, *The Thrid IEEE Symposium on Parallel and Distributed Processing*, Dallas, December 5, 1991.

"Scientific Libraries for Scalable Architectures", *2nd BLACS Workshop*, Cornell University, Cctober 14-15, 1991.

"Scientific Libraries for Scalable Architectures", Distinguished Lecturer, *the Minnesota Supercomputer Institute*, University of Minnesota, Minneapolis, October 2, 1991.

"Techniques for Efficient Data Motion in Large Scale Distributed Memory Systems", Workshop on *Interconnection Networks*, Marseille, July 15-19, 1991.

"Performance Modeling of Distributed Memory Architectures", Workshop on *Conceptual Models of Parallel Scientific Computation*, Seattle, June 27-29, 1991.

"Language and Compiler Issues in Building Scalable High Performance Scientific Libraries", NSF-NCRD Workshop on *Advanced Compilation Techniques for Novel Architectures*, Kiryat-Anavim, Israel May 27-30, 1991.

" Data Parallel Programming: Programming Primitives and Performance", Tutorial at the Symposium on *Principles and Practices of Parallel Programming*, PPoPP91, Williamsburg, VA., April 21 1991.

"Communication in Distributed Memory Architectures", workshop on *Basic Linear Algebra Communication Subroutines*, Houston, March 28, 1991.

"Making Fortran 90 work fast", workshop on *DARPA/ISTO Software PI Meeting*, Warwick, RI, February 26-29, 1991.

"Communication Primitives for Distributed Data Structures", workshop on *Global Climate Modeling*, the National Center for Atmospheric Research, Boulder, January 9-10, 1991.

1990

"Software Libraries for Scalable Supercomputers", workshop on *Reliable Large Scale Scientific Computation*, Rensselear Polytechnic Institute, Troy, December 11-12, 1990.

"Software Libraries for Data Parallel Languages", workshop on *Parallel Processors in Meteorology*, Reading, England, November 26-30, 1990.

"The Connection Machine Scientific Software Library", Los Alamos National Laboratories, Los Alamos, November 16, 1990.

"Scientific Supercomputing and Computer Science in the 1990'ies", Harvard University, Cambridge, November 8, 1990.

"Scientific Applications on Data Parallel Architectures: Techniques for High Performance", Princeton University, Princeton, November 5, 1990.

"Communication Libraries", Workshop on *Scalable Parallel Libraries*, Oak Ridge National Laboratories, Oak Ridge, September 6-7, 1990.

"Obstacles to the Development of Parallel Libraries", Workshop on *Scalable Parallel Libraries*, Oak Ridge National Libraries, Oak Ridge, September 6-7, 1990.

"Linear Algebra on Data Parallel Architectures" *The Northeast Parallel Architectures Center Summer Institute*, Syracuse University, Syracuse, July 25, 1990.

"The Connection Machine Scientific Software Library", *The Northeast Parallel Architectures Center Summer Institute*, Syracuse University, Syracuse, July 25, 1990.

"Issues in the design of a Scientific Library", *Householder Symposium XI*, Tylösand, Sweden, June 18-22, 1990.

"Basic Array Operations" *Householder Symposium XI*, Tylösand, Sweden, June 18-22, 1990.

"The Symmetric Eigenproblem" *Householder Symposium XI*, Tylösand, Sweden, June 18-22, 1990.

"Implementation on the Connection Machine - Experiences" *Householder Symposium XI*, Tylösand, Sweden, June 18-22, 1990.

"Teraflop computation: Distributed and Shared Memory", Workshop on Acceleration Algorithms, Boston University, April 13, 1990.

"Connection Machine Applications", The Royal Institute of Technology, January, 1990.

1989

"Data Parallel Supercomputing", Cornell University, Ithaca, New York, October 26, 1989.

" Data Parallel Supercomputing", Argonne National Laboratories, Mathematical and Computational Sciences Division, October 3, 1989.

"Graph Embeddings on Hypercubes", University of Chicago, Department of Computer Science, October 2, 1989.

"Graph Embeddings on Hypercubes, NEC Research Institute, Princeton, September 25, 1989.

"Data Parallel Supercomputing", Amoco Research, Tulsa, September 21, 1989.

"Graph Embeddings on Hypercubes", University of Tulsa, Tulsa, September 21, 1989.

"Fluent Supercomputing", Second Swedish Workshop on Computer Systems Architecture", Bålsta, Sweden, August 21-23, 1989.

"Graph Embeddings on Hypercubes", Brown University, Providence, RI, August 10, 1989.

"A Linear Algebra Library for the Connection Machine", *SIAM Annual Meeting*, San Diego, CA, July 17-21, 1989

"Data Parallel Supercomputing", *Conference on Preconditioned Conjugate Gradient Methods*, Universty of Nijmegen, Holland, June 19-21, 1989.

"High Performance Computing", *The Seventh ARMY Conference on Applied Mathematics and Computing*, West Point, New York, June 7, 1989.

"Scientific Applications on the Connection Machine", *RIACS*, Moffet Field, CA, May 10, 1989.

"Data Parallel Supercomputing", *CERFACS*, Toulousse, France, April 26, 1989.

"Scientific Applications on the Connection Machine", *The Royal Institute of Technology*, Stockholm, Sweden, February 9, 1989.

"Solving the Wide-Angle Wave Equation on a Data Parallel Computer", *Second IMACS Symposium on Computational Acoustics*, Princeton University, Princeton, New Jersey, March 1989.

5. Refereed conference papers and book chapters

"Massively Parallel Computing: Mathematics and Communications Libraries", to appear in *Parallel Computing in Meteorology*, World Scientific, 1993.

"Massively Parallel Computing: Data distribution and communication", to appear in *Parallel Architectures and their Efficient Use*, Springer Verlag, 1993

"Language and Compiler Issues in Scalable High Performance Libraries", to appear in *Compilation Techniques for Novel Architectures*, Springer Verlag, 1993.

"Matrix Multiplication on Hypercubes Using Full Bandwidth and Constant Storage", (with Ching-Tien Ho), in Proceedings of the *Sixth Distributed Memory Computing Conference*, pp. 447-451, IEEE Computer Society Press, April, 1991.

"Maximizing Channel Utilization for All-to-All Personalized Communication on Boolean cubes", (with Ching-Tien Ho) in Proceedings of the *Sixth Distributed Memory Computing Conference*, pp. 299-304, IEEE Computer Society Press, April, 1991.

"Embedding Three-Dimensional Meshes in Boolean Cubes by Graph Decomposition", (with Ching-Tien Ho), in Proceedings of *The 1990 International Conference on Parallel Processing*, pp. 319-326, IEEE Computer Society, August, 1990.

"Embedding Meshes into Small Boolean Cubes", (with Ching-Tien Ho), in Proceedings of *The Fifth Distributed Memory Computing Conference*, pp. 1366-1374, IEEE Computer Society, April, 1990.

"The Complexity of Reshaping Arrays on Boolean Cubes", (with Ching-Tien Ho), Proceedings of *The Fifth Distributed Memory Computing Conference*, pp. 370-377, IEEE Computer Society, April, 1990.

"Supercomputers: Past and Future", in *KOSMOS*, pp. 31-44, Almquist&Wiksell, Uppsala, 1990.

"Optimizing Tridiagonal Solvers for Alternating Direction Methods on Boolean Cube Multi-processors", (with Ching-Tien Ho), Proceedings of the *Fourth SIAM Conference on Parallel Processing for Scientific Computing*, pp. 96-98, December 11, 1989. SIAM 1990.

"Data Parallel Algorithms for the Finite Element Method", (with Kapil K. Mathur), Proceedings of the em Fourth SIAM Conference on Parallel Processing for Scientific Computing, pp. 257 - 267, December 1989. SIAM 1990.

"QCD with Dynamical Fermions on the Connection Machine", (with Clive Baillie, Ralph Brickner, Rajan Gupta), *Supercomputing 89*, ACM Press, pp. 2-9, November 1989.

"Dilation d Embeddings of a Hyper-Pyramid into a Hypercube, (with Ching-Tien Ho), *Supercomputing 89*, ACM Press, pp. 294-303, November 1989.

"Element Order and Convergence Rate of the Conjugate Gradient Method for Stress Analysis on the Connection Machine", (with Kapil K. Mathur), *Supercomputing 89*, ACM Press, pp. 337-343, November 1989.

"Matrix Multiplication on the Connection Machine", (with Tim Harris and Kapil K. Mathur), *Supercomputing 89*, ACM Press, pp. 326-332, November 1989.

"A Radix-2 FFT on the Connection Machine", (with Robert Krawitz, Roger Frye and Doug MacDonald), *Supercomputing 89*, ACM Press, pp. 809-819, November 1989.

"A study of Dissipation Operators for the Euler Equations and a Three-dimensional Channel Flow", (with Pelle Olsson), *Supercomputing 89*, ACM Press, pp. 141-151, November 1989.

"The Finite Element Method on a Data Parallel Architecture", (with Kapil K. Mathur), in *Fifth International Symposium on Numerical Methods in Engineering*, September 1989.

"Node Orderings and Concurrency in Structurally-Symmetric Sparse Problems", (with I.S. Duff), in *Parallel Supercomputing: Methods, Algorithms and Applications*, pp. 177-189, Wiley, 1989.

"Optimal Communication in Network Architectures", in *VLSI Frontiers: Massively Parallel Models of Computation* by Morgan Kaufmann Publishers, pp. 223-389, 1990.

"Data Parallel Supercomputing", in *Use of Parallel Processors in Meteorology*, Springer-Verlag, 1989.

6. Poster presentations

"Matrix Multiplication on Hypercubes Using Full Bandwidth and Constant Storage", Ching-Tien Ho and S. Lennart Johnsson, The Sixth Distributed Memory Computing Conference, Portland, OR., April, 1991.

"Maximizing Channel Utilization for All–to–All Personalized Communication on Boolean cubes, S. Lennart Johnsson and Ching-Tien Ho, The Sixth Distributed Memory Computing Conference, Portland, OR., April, 1991.

"CMIS Arithmetic and Multiwire NEWS for QCD on the Connection Machine", Clive F. Baillie, Ralph G. Brickner and S. Lennart Johnsson, Supercomputing 90, New York, November, 1990.

"The Complexity of Reshaping Arrays on Boolean Cubes", The Fifth Distributed Memory Computing Conference, April 8-12, 1990, Charleston, SC.

"High Performance Matrix Operations for QCD on the Connection Machine", Ralph Brickner and S. Lennart Johnsson, Supercomputing 89, Reno, CA.

7. Unrefereed conference papers, and technical reports

"All–to–All Communication on the Connection Machine system CM–200", (with Kapil K. Mathur), Thinkning Machines Corp. Technical Report TR-243, November 1992.

"Index Transformation Algorithms in a Linear Algebra Framework", (with Alan Edelman and Steve Heller) Technical Report 212, Thinking Machines Corp., March 1992. Submitted to the IEEE Transactions on Parallel and Distributed

Computing.

"Multiplication of Matrices of Arbitrary Shape on a Data Parallel Computer", (with Kapil K. Mathur), Thinking Machines Corp., Technical Report 216, December 1991. Submitted to J. of Parallel Computing. (Harvard University Technical Report TR-01-92).

"On the Conversion between Binary Code and Binary Reflected Gray Code", (with Ching-Tien Ho), Harvard University TR-20-91, July 1991. Submitted to IEEE Transactions on Computers.

"Communication and I/O Libraries", presented at DARPA Workshop on *Scalable Scientific Libraries*, September, 1990. Technical Report TR-02-91, Harvard University, January 1991.

"True Hypercube Algorithms on the Connection Machine" (with Alan Edelman, Mark Bromley, and Steve Heller), *Parallel Computing: Achievements, Problems, and Prospects*, Capri, Italy, June 3 - 7, 1990.

"The Connectic Machine Scientific Software Library" (with Anne Trefethen and Kapil K. Mathur), *Fourth SIAM Conference on Parallel Processing for Scientific Computing*, December 12, 1989, Chicago, IL.

"The Finite Element Method on a Data Parallel Architecture" (with Kapil K. Mathur), *Fourth SIAM Conference on Parallel Processing for Scientific Computing*, December 12, 1989, Chicago, IL.

"A Data Parallel Implementation of an Explicit Method for the 3-Dimensional Compressible Navier-Stokes Problem", (with Pelle Olsson), *Fourth SIAM Conference on Parallel Processing for Scientific Computing*, December 11, 1989, Chicago, IL.

"Matrix Multiplication on a Data Parallel Architecture", (with Kapil K. Mathur and Tim Harris), *Fourth SIAM Conference on Parallel Processing for Scientific Computing*, December 11, 1989, Chicago, IL.

"A Radix-2 FFT on the Connection Machine", (with Robert L. Krawitz, Roger Frye and Doug MacDonald), *Fourth SIAM Conference on Parallel Processing for Scientific Computing*, December 11, 1989, Chicago, IL.

"High radix FFT on Boolean cube networks", (with Michel Jacquemin and Ching-Tien Ho), Department of Computer Science, Yale University, Technical Report YALEU/DCS/RR-751, November 1989.

"Multiplying of Arbitrarily Shaped Matrices on Boolean Cubes Using the full Communications Bandwidth", (with Ching-Tien Ho) Department of Computer Science, Yale University, Technical Report YALEU/DCS/RR-721, July 1989.

8. Ph.D. Thesis Committees

1992 Zdenek Johan: Data Parallel Finite Element Techniques for Large-Scale Computational Fluid Dynamics, Stanford Univers
Michel Jacquemin: Compiling for Distributed Memory Machines, Yale University.

1991	Markus Wloka: Parallel VLSI Synthesis, Brown University.
1990	Dimitris Gerogiannis: Efficient Implementation of Intermediate Level Image Analysis Tasks on Parallel Machines, Yale University
1989	Yiwan Wong: Algorithms for Systolic Array Synthesis, Yale University

9. Editorial Work

- 1991-present:
  Editorial Board, International Journal of Supercomputer Applications.
- 1991-present:
  Editorial Advisory Board, Journal of Scientific Programming.
- 1990-present:
  Editorial Board, Journal for Numerical Linear Algebra with Applications.
- 1988-present:
  Editorial Board, Journal on Concurrency: Practice and Experience.
- 1988-present:
  Editor, International Journal on High Speed Computing.
- 1984-present:
  Editor, Journal of Parallel and Distributed Computing.

10. Boards and Committes

1992-	Computing Research Association, Board Member
1991-1992	ICASE Search committee for new Institute Director.
1990-	Science Council for Applied Mathematics and Computer Science, Universities Space Research Administration.
1991-1992	Organizing committee 7th IMACS International Conference on Computer Methods for Partial Differential Equations, June 22-24, 1992.
1991-1992	Program committee Scalable High Performance Computing Conference, April 26-29, 1992.

1991-1992	Program committee Sixth International Parallel Processing Symposium, March 23-26, 1992.
1990-1991	Program committee Symposium on Parallel Algorithms and Architectures, SPAA 91.
1990-1991	Organizer, Minisymposia on International Conference on Industrial and Applied Mathematics, ICIAM 91, July 8-12, 1991, Washington D.C.
1990	Chair, Workshop on Communication and I/O Libraries Symposium on Scalable Libraries, Oak Ridge National Laboratories, September 5 - 7, 1990.
	Organizing committee, Very Large Scale Computations in the 21st Century, VLSC21, Cape Cod, September 3-5, 1991.
	Organizer, Minisymposia on Large Scale Scientific Computation Linear Algebra on Data Parallel Architectures, Householder Symposium XI, Tylösand, Sweden, June 1990.
	Organizing committee, The 1990 Conference on Distributed Memory Architectures. Charleston S.C., April 1990.
1989	Session chairperson, Massively Parallel Computation, SIAM Conference on Parallel Processing for Scientific Computing. Chicago, IL., December 1989.
	Program committee, the 1989 International Conference on Supercompu Crete, Greece, July 1989.

Final Report for AFOSR Grant AFOSR-89-0382 with Yale and Harvard Universities

List of Reports/Reprints

Harvard University Technical Reports

TR-01-91

*QCD on the Connection Machine: Beyond *LISP*

Ralph G. Brickner
Clive F. Baillie
S. Lennart Johnsson

TR-02-91

Communication and I/O Libraries

Chair: Lennart Johnsson
Scribe: Patrick Worley

TR-18-91

Optimal All-to-All Personalized Communication with Minimum Span on Boolean Cubes

S. Lennart Johnsson
Ching-Tien Ho

TR-20-91

On the Conversion Between Binary Code and Binary-Reflected Gray Code on Boolean Cubes

S. Lennart Johnsson
Ching-Tien Ho

TR-23-91

Minimizing the Communication Time for Matrix Multiplication on Multi-Processors

S. Lennart Johnsson

TR-25-91

Communication Efficient Multi-Processor FFT

S. Lennart Johnsson
Michel Jacquemin
Robert L. Krawitz

TR-02-92

A Data Parallel Finite Element Method for Computational Fluid Dynamics on the Connection Machine System

Zdeněk Johan
Thomas J.R. Hughes
Kapil K. Mathur
S. Lennart Johnsson

TR-04-92

Block-Cyclic Dense Linear Algebra

Woody Lichtenstein
S. Lennart Johnsson

TR-07-92

Index Transformation Algorithms in a Linear Algebra Framework

Alan Edelman
Steve Heller
S. Lennart Johnsson

TR-09-92

Local Basic Linear Algebra Subroutines (LBLAS) for Distributed Memory Architectures and Languages with Array Syntax

S. Lennart Johnsson
Luis F. Ortiz

TR-16-92

Optimal Communication Channel Utilization for Matrix Transposition and Related Permutations on Binary Cubes

S. Lennart Johnsson
Ching-Tien Ho

TR-18-92

Language and Compiler Issues in Scalable High Performance Scientific Libraries

S. Lennart Johnsson

TR-20-92

An Efficient Algorithm for Gray-to-Binary Permutation on Hypercubes

Ching-Tien Ho
S. Lennart Johnsson
M.T. Raghunath

TR-29-92

Massively Parallel Computing: Data distribution and communication

S. Lennart Johnsson

TR-01-93

Massively Parallel Computing: Mathematics and communications libraries

S. Lennart Johnsson
Kapil K. Mathur

Thinking Machines Corporation Technical Reports

Thinking Machines Corporation TR BA88-2

Shuffle Permutations on Boolean Cubes

S.L. Johnsson
C.T. Ho

Thinking Machines Corporation TR BA90-1

Boolean Cube Emulation of Butterfly Networks Encoded by Gray Code

S.L. Johnsson
C.T. Ho

Thinking Machines Corporation TR BA90-2

The Complexity of Reshaping Arrays on Boolean Cubes

S.L. Johnsson
C.T. Ho

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Embedding Meshes into Small Boolean Cubes

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